THE MOISTURE IN THE AIR WE BREATHE

Dr. Gulick's letter about the air we breathe in buildings, in the March number of Science, calls attention to some difficulties that have been troublesome to many of us for a long time.

During the winters of 1896–7 and 1897–8, I made a series of observations in office, residential and school buildings in Milwaukee, Wis., giving particular attention to the humidity during the period of artificial heating. The results of this preliminary study were published in a condensed form in U. S. Weather Bureau Bulletin, No. 24, in 1899. Later observation and study tend to confirm most of the conclusions reached at that time, but have failed utterly to furnish a satisfactory answer to that most important and all-including question, why in-door living is less healthy than out-door living. Certainly, there is some condition of environment, inimical to health, seemingly brought about by artificial heating that, thus far, has escaped observation.

The most obvious difference between inside and outside air appears to be in the moisture content, and, as Dr. Gulick asks a number of pointed questions about this important constituent of the atmosphere, a non-technical statement of the generally accepted view may be of interest.

Unfortunately the terminology used to express various conditions of atmospheric moisture was invented before we knew as much as we now think we know about the several factors involved, and, therefore, instead of assisting to a proper understanding tend to confusion.

1. The expression, capacity of air for moisture, is misleading. A better expression is, capacity of space or vapor for moisture, because the presence of air in space has nothing whatever to do with the capacity of the space for moisture, the only effect of the presence of air being to retard the diffusion of moisture within the space.

2. Likewise, the expression, saturation of air, implies that the presence of air affects the amount of moisture required to saturate a given space, which is not the case. It is a rather curious fact that, although atmospheric air is a mixture of nine or ten different gases, each gas, including vapor of water, tends to arrange itself according to its density and acts in all respects as it would if no other gas was present. In other words, each gas forms an atmosphere about the earth independent of all other gases. We, therefore, may eliminate dry air from consideration because it is not a factor in the problem.

To assist in obtaining a definite view let us imagine a cylinder of space 50 feet in diameter extending upward from the surface of a lake a distance of 10 miles, which is about as high as vapor will rise to an appreciable extent in our atmosphere. We will assume that the average temperature of the space within the cylinder is 40° F., and that the temperature of the surface of the lake is the same. How does the water in the form of vapor pass from the lake into this space? The molecular theory of matter teaches that the molecules of water are in a constant state of agitation; that the velocity and amplitude of their vibrations varies with the temperature, being greater for high temperatures than for low temperatures; and that some of the molecules in darting about attain a velocity and direction that carry them beyond the attraction they have for each other, and, hence, they fly off into the space above the water. This is our understanding of the process of evaporation. But it so happens that these molecules of water in the form of vapor do not escape the control of gravity, which operates to pull them down toward the earth in accordance with their weight or density. As the molecules continue to escape and a greater number pass into the space, they impinge more and more upon the surface of the water and increasingly impede the escape of other molecules from the surface, so that the process of evaporation becomes slower and slower. It, however, does not cease entirely, because the molecules of vapor also are in a constant state of agitation, and, in darting about and beat-

ing upon each other, some are carried into the water by their own velocity and some are thrown into the water by the force of the blows received from other molecules, thus decreasing the number in the vapor and allowing others to escape from the water. When the number that escape and the number that are carried and thrown back into the water equal each other a condition of equilibrium is established and the space is said to be saturated.

If the temperature of the space or the vapor within the space now be raised, what will happen?

The molecules of vapor at a temperature of 40° F. have a given velocity and amplitude of motion. The increase of the temperature from 40° to 50° increases their velocity and movement, and to exercise this increased activity requires more space. We, therefore, are accustomed to say that the vapor expands or increases in volume when its temperature is raised. In expanding some of the vapor overflows the original space, and the number of molecules within the space is thus decreased by the number that has been crowded out of the cylinder. This destroys the condition of equilibrium and permits the molecules at the surface of the water to escape again in greater numbers. Thus, the process of evaporation continues, establishing finally as before a condition of equilibrium at the new temperature of 50° F. This is our understanding, why increased temperature gives increased capacity when the vapor is free to expand, except for the control of gravity. But if we put a lid on the cylinder and thus confine the vapor to a definite space we limit the field of its activity but not the activity itself. The effort of vapor, humidity, steam, water gas—whatever name we may use to designate it—to obtain more space increases with its temperature whether confined within a limited space or not. If the space is limited the effect is increased pressure; if not limited increased volume. In either case it obeys the laws of gases. The only difference between atmospheric moisture and steam is that the activities of the former are limited by gravity alone, while the activities of the latter are confined to a definite space.

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A VARIANT IN THE PERIODICAL CICADA

While collecting material for a study of the mode of pigment formation in the periodical cicada (*Tibicen septendecim* L.) my attention was attracted by an adult male in whose eyes the red pigment was lacking. The specimen was secured at Summit, N. J., on June 6, and although the cicadas occurred there in countless thousands I searched in vain for a second specimen.

The example secured differed from the usual form not only in lacking the red pigment of the eyes, which in this specimen are perfectly white, but also in the coloration of the wing veins. In this individual the costa of the fore wings and the costa and the greater portion of the radius and media of the hind wings lack the typical orange coloration and are perfectly colorless.

Morgan[1] has recently caused white-eyed mutants to occur in *Drosophilia* by closely inbreeding and it may be that this specimen originated in the same manner if we assume that the entire colony is descended from one pair of cicadas. A study of the inheritance of this trait would be very interesting, but such a study is obviously impracticable owing to the long period of adolescence.

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QUOTATIONS

TRIPPED BY RED TAPE

That the Department of Agriculture should be in danger of losing three of its leading experts on food adulteration, Wiley, Bigelow and Rusby, on account of a technical violation of the salary regulations, shows how a government is hampered by its bureaucratic methods. It is not claimed that Professor Rusby, of Columbia University, was avaricious in refusing to work for $9 a day or that the departmental authorities who arranged for him to be paid at the rate of

[1] Morgan, Science, N. S., XXXIII., No. 849, p. 534, April 7, 1911.